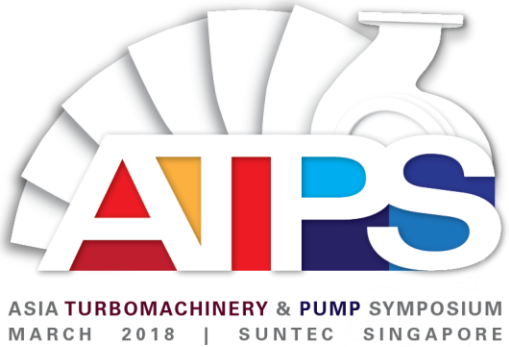

Rotor magnetization in Turboexpander and its effect on Vibration readings

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Presenter: Ajay Kumar

Ajay Kumar is a Mechanical engineer with specialization in Rotating machinery. He has been involved in variety of engineering consultation activities like Root cause analysis, Asset life study, Asset integrity, safety audits, Machinery operational performance and Training & capability assessment. Ajay has rich 22 years of field experience working as maintenance engineer in an Ethylene plant in India, FSR with Turboexpander OEM and Rotating machinery specialist in PETRONAS, Malaysia. Currently he is working as freelance consultant.

Presentation outline:

- **Abstract**
- **Case study**
  - Issues and background
  - Observations
  - Approach and analysis
  - Resolution
- **Conclusions**
- **Lesson learnt**

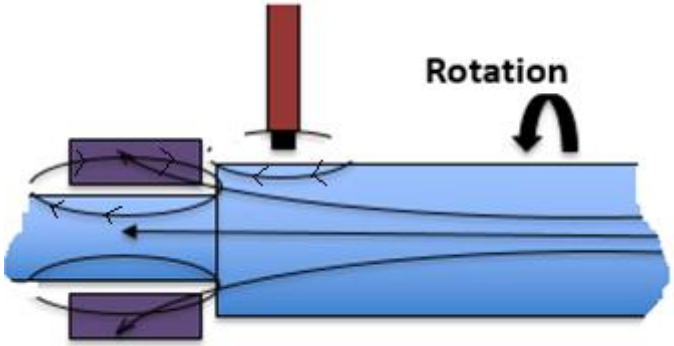
Abstract:

A magnetized rotating machine behaves like an electrical generator. It often produces localized stray current that usually discharges across small clearance paths imposing damage to machine internals and vibration probes. In several cases, this has also resulted in erroneous vibrations reading that can cause misguided decisions leading to unplanned downtime, waste of resources and significant production loss.

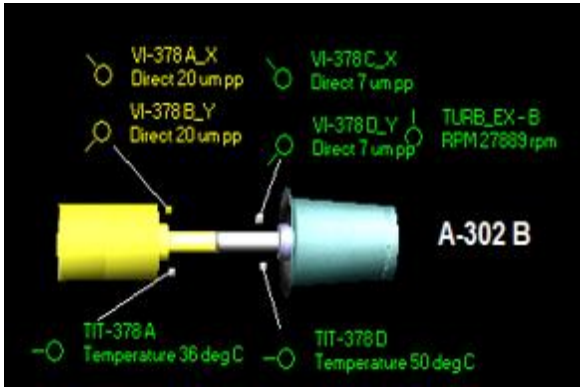
Turboexpanders are high speed radial expansion turbines and are very sensitive to any residual magnetism in the rotor. A case studies has been discussed in this presentation involving rotor magnetization and it focuses on source of magnetism, failure modes, problem identification and successful resolution of the issue. Lesson learnt from the incident is also being shared. If the problems is diagnosed early, costly outage can be averted by adopting proper maintenance practices.

Illustration: Magnetically induced current in a Rotor

- In a magnetized rotating machinery, relative movement between stator and rotor in presence of magnetic field produces eddy and circulating currents.
- These currents form an internal loop. Such current loops reinforce the magnetic field, which further increase the induced current generation.
- The induced current affects readings from a conventional eddy current vibration probe.



Case Study- Turboexpander in Ethylene Plant



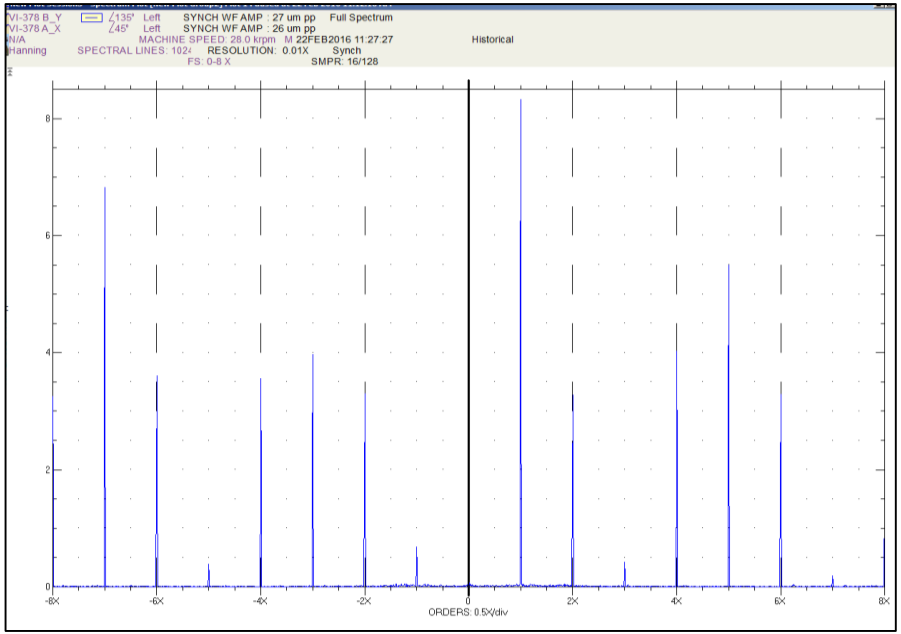
Expander Compressor unit
Expander speed: 44,000 RPM
Loaded by centrifugal compressor
Power: 250 KW
Commissioned in 2009

- Expander is used for isentropic expansion of tail gas for recovery of ethylene and process refrigeration (-150 deg C)).
- This unit was operating with degraded performance for last one year resulting loss in ethylene production of about 4MT/ day.
- It was decided to overhaul and replace all worn out internals to recover expander efficiency.
- Expander assembled with new internals with OEM specified clearances.

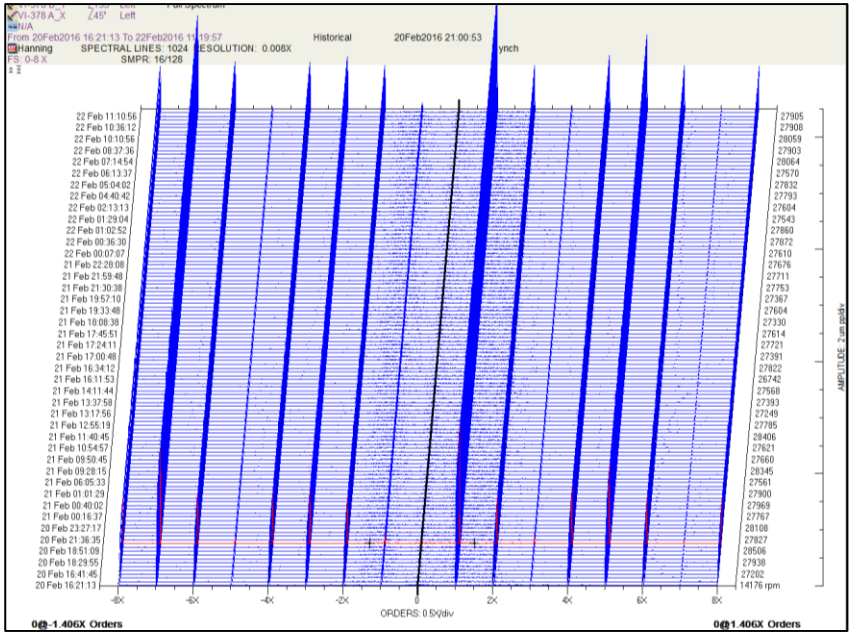
Observations (1/4):

- During Expander start up, all operating parameters were normal till it reached speed around 20000 RPM.
- With further increase in guide vanes to achieve operating speed of 44000 RPM, the Expander suddenly tripped at around 25000 RPM on high radial vibration at Expander end.
- Study of Vibration Spectrum indicated vibration peaks at 1X, 2X, 4X, 5X and 6X.
- 1X was dominant but 1X vibration amplitude was only 6 microns peak to peak. However, due to presence of multiple synchronous peaks, direct value added up to exceed trip limit of 40 microns.
- Few plots are shown in the following slides to depict vibration behaviour.

Observations (2/4):

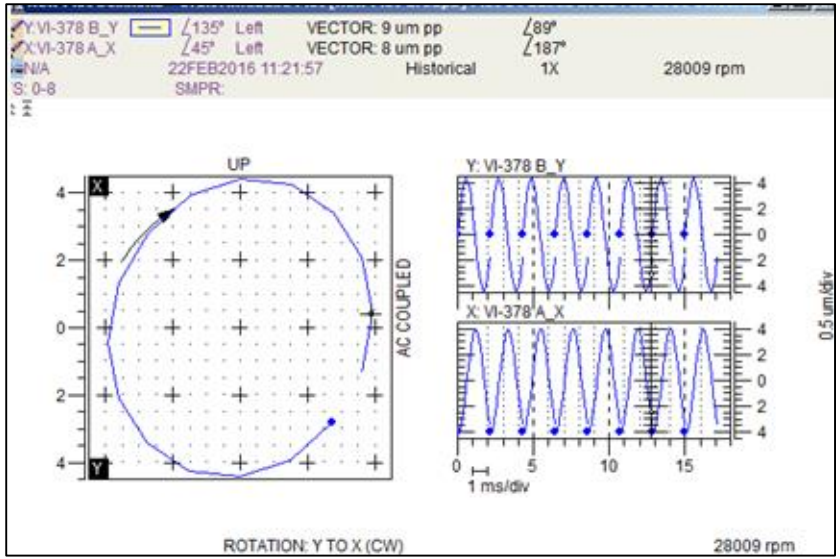


1.1 VI 378 X/Y; Full spectrum
Direct Vibration Amp 25/27 microns @25kRPM

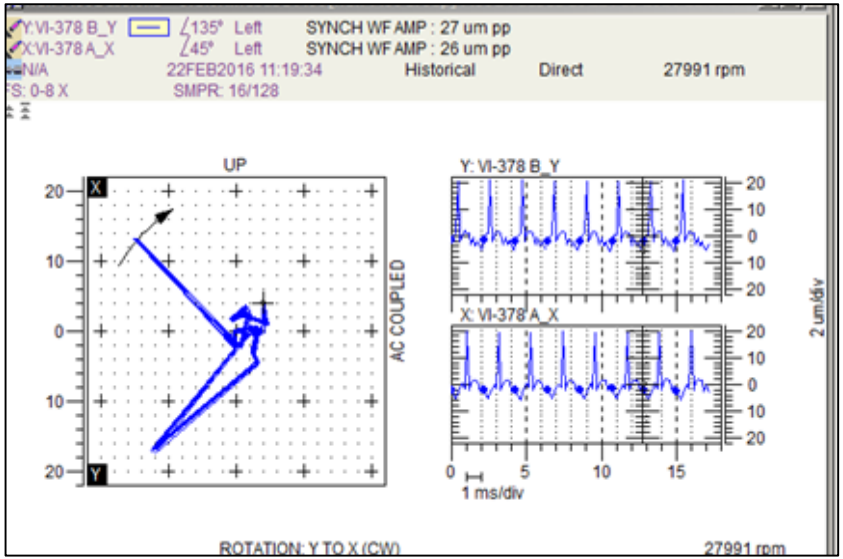


1.2 VI 378 X/Y; Waterfall diagram
Direct Vibration Amp 25/27 microns

Observations (3/4):

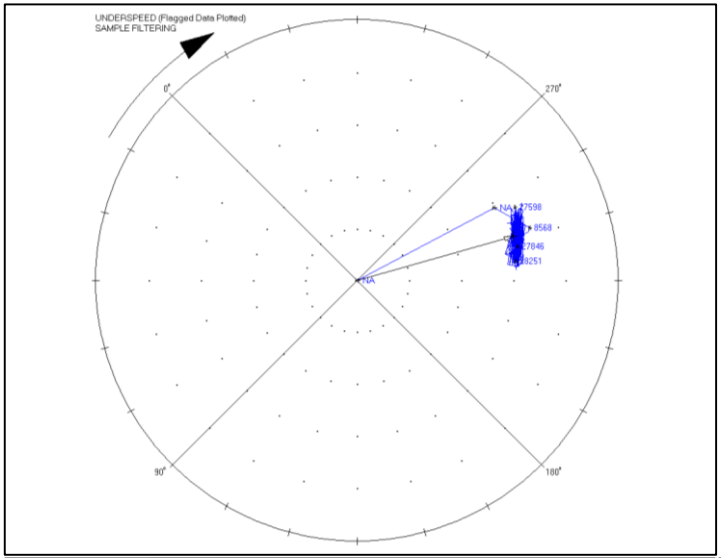


1.3 VI 378 X/Y ; Orbit Plot 1X at 28009 RPM
1X Vibration Amp 8/9 microns

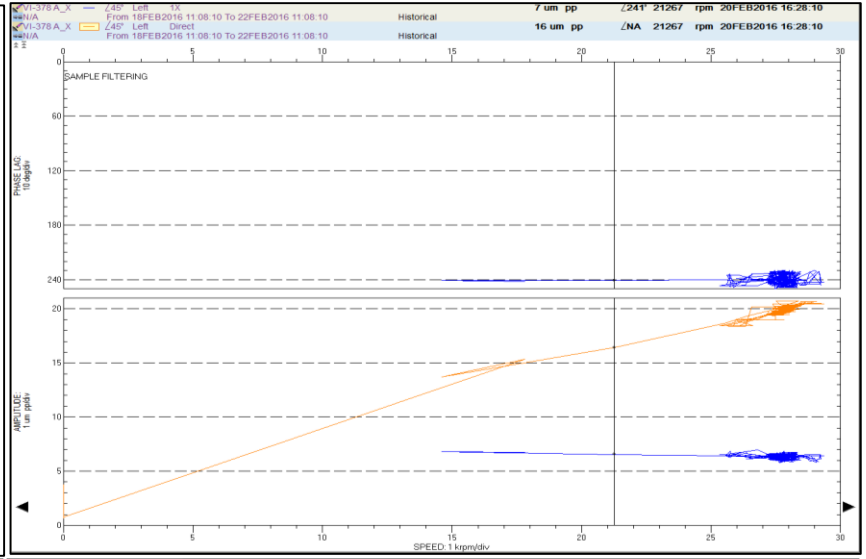


1.4 VI 378 X/Y; Orbit Plot at 27991 RPM
Direct Vibration Amp 26/27microns

Observations (4/4):

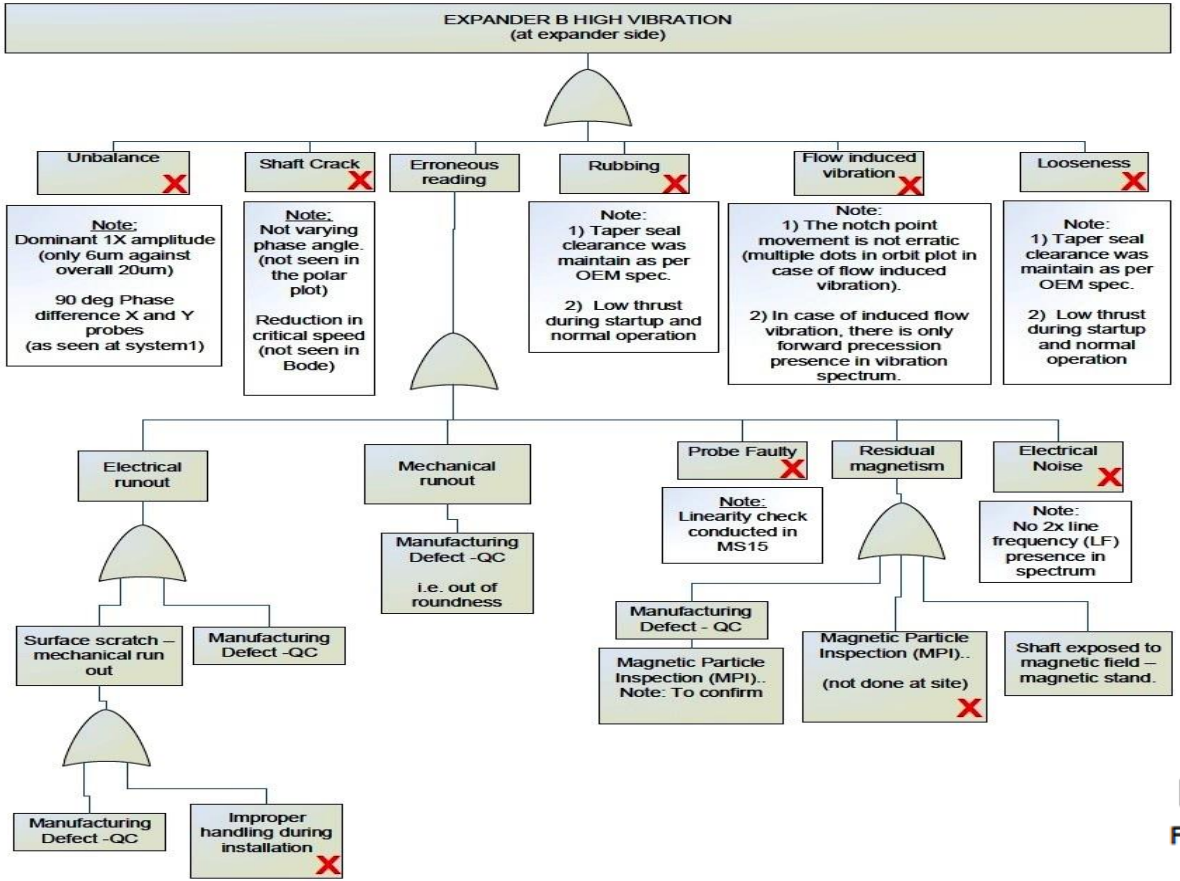


1.5 VI 378 X/Y
Polar Plot, 1X Vibration Amplitude



1.6 VI 378 X/Y
Bode Plot, 1X and direct Vibration Amplitude

RCA- Fault Tree Analysis



Approach and Analysis:

- Systematic root cause analysis was done to identify and eliminate possible causes.
- Based on investigation and findings following possibilities were ruled out:-
  - Unbalance
  - Shaft crack
  - Rubbing
  - Flow induced vibration
  - Faulty vibration system
  - Mechanical Run out
- There was no record of Electrical run out of the shaft. It was decided to disassemble the unit for internal inspection.

Findings:

- No rubbing marks at shaft journal and vibration probe target area.
- Bearing pads were found in good condition with no rubbing marks.
- Seal and Labyrinths were found in good condition.
- *Gauss value checking of expander shaft indicated high residual magnetism (> 10 Gauss) near vibration probe target areas and near journals.*

<u>On further checking it was found that:-</u>

- Out of three new shafts in the inventory, two were found with high residual magnetism. (Gauss > 10). Only one new shaft was found within acceptable gauss value of < 2 Gauss.
- Unfortunately, during recent assembly, residual magnetism of the shaft was not measured as it was not included in the quality checks for assembly with new shaft.

Resolution:

- The Expander was assembled with new shaft with acceptable gauss value.
- Dynamic balancing of Rotor was verified and found in accordance within ISO grade G.1.0
- All grounding connections were rechecked and found okay.
- Expander was restarted successfully and could be able to achieve its normal operating speed of 44000 RPM with stable vibration and normal operating parameters.

Conclusions

- Undesired magnetism in machinery accounts for many unexpected issues including erroneous vibration readings in machinery fitted with proximity probes (Eddy current probes).
- Severity of the issue depends on magnitude of residual magnetism, size and rotating speed of the machinery.
- In most of the cases, residual magnetism resides due to improper handling/ storage, negligence during field installation or inadequate quality checks during manufacturing and inspection.
- Due to non specific nature of magnetically induced erroneous vibration, this is a difficult task to identify the issue when machine is in operation. Therefore any residual magnetism must be checked and corrected before the machine is put in operation after a maintenance, especially for high speed machinery.

Lesson Learnt

- In case study discussed here, vibration value suddenly jumped above the trip limit. (instead of gradual increase in vibration with increase in RPM).
- Maintenance procedure was modified to include checking of residual magnetism in rotor and other internals during machine assembly, even for newly procured items.
- Careful use of Magnetic chuck/ magnetic base during inspection and assembly.
- Checking and maintenance of shaft grounding connections on a regular basis to ensure proper protection.
- Sharing of information or any unusual observation among team members.

THANK YOU

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